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Feasibility Of Redwood Wood For Paper Production And The Effects Of Beating On Paper's Properties

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***Abstract*—In this study, handsheet papers have been manufactured by using Redwood (Seqoia sempervirens D.Don) wood. Four cookings were carried out at different NaOH/Na_2 ratios which were 23/27, 24/26, 26/24 and 27/23 respectively. Cooking temperature was selected 170ºC as fixed. The screened yield of these pulps has been calculated to be 50.30% 49.00%, 45.30% and 43.00% respectively. From these pulps, paper was produced at 16±2, 35 and 50SR°. When compared to unbeaten samples, the opacity value and brightness decreased, while the SR° degree increased.**

Keywords—redwood, pulp, beating, paper

I. Introduction

While making paper for general use from a raw material, the issue of which properties of the paper should be high and which should be low can be conflicting and confusing. For example, sanitary papers are expected to have high water absorption capacity, and packing papers are expected to have low absorption capacity. However, while determining the optimum conditions in making pulp, pulps that have the highest yield are preferred. It has become a tradition to prefer and accept pulp, which paper is produced from, with the best mechanical and optical values. While producing paper from any pulp, many of the characteristics of paper are determined via beating. In other words, paper is produced in beater. For this reason, in order to determine the characteristics the paper will gain at different beating degrees, the most appropriate beating level was determined in our study by producing paper from unbeaten pulp (16±2^{0}SR) and pulps beaten at beating degrees of 35 and 50^{0}SR.

II. Literature Review

Istek and Ozkan [1] indicated that pulping from European Aspen using kraft method cooking temperature was 170ºC. Martin [2] found that pulping from redwood using kraft method chemical of 24.84 percent, sulfidity of 25 percent, and an active alkali of 19. 38 percent were chosen. The liquor-wood ratio was 6.5 to 1. The maximum temperature was 160° C, and the time required to reach the maximum temperature was 180 minutes, and total time was 390 minutes. According to literature, cooking temperature 170° C may be chosen.

III. Problem Identification

One of the criteria of paper production from any lingo-cellulosic raw-material is the length of the fiber. Softwood wood has longer fiber than hardwoods [3]. Moreover, softwood species have more uniform fibers than hardwoods. However, softwood pulp is used for bag paper production. In this study, it has been aimed to produce paper from redwood, which is important softwood species in the pulp and paper industries. The fiber length has positive effects on paper's mechanical properties. However, extremely long fibers cause formation defects in paper production. On the other hand, beating of pulp changes fiber length. For this reason, different beating degrees must be carried out.

IV. Methodology

4.1 Material Supply

The Redwood (Sequoia sempervirens D.Don) wood used in this study was obtained from north east exposure at 160 m altitude at coordinates of 41°00´ N, 39°38´E . NaOH and Na_2S used in pulp production were obtained from MERCK Darmstadt –Germany. After the trees were felled, wood samples were cut into 5cm cylinders in longitudinal direction, and shredding process was executed manually.

4.2 Pulp Production

Cooking has been carried out within a lab-type cooking boiler having 2-rpm speed. While producing pulp from redwood chips, the $NaOH/Na_2S$ ratios have been selected as 23/27, 24/26, 26/24 and 27/23. The production parameters for this study were as follows; solution/stalk ratio as 5/1, cooking temperature as 170±2˚C, and coking duration as 180 min. The maximum temperature has been achieved in 90 minutes in cooking operation, and continued for 90 minutes at this temperature.

4.3 Handsheet Production

Handsheets which are having 2.4 g weight have been manufactured in Rapid- Köthen lab-type machine from unbeaten pulp (16±2SR°) and Hollander beaten pulps at up to 35 ad 50SR°. Smoothness [4] brightness [5] and opacity [6] properties and tear index [7], burst index [8] and breaking length [9] values of the paper have been determined.

V. Results and Discussion

Pulp yield of any lignocellulosic material is the most important criterion in the pulping process. In our study, the highest screened pulp yield was determined as 47.30% in which $NaOH/Na_2S$ ratio was 23%/27% respectively. In table 1, pulp yields of cooking are presented.

TABLE I. Total and Screened Pulp Yield of Redwood

Cooking - $NaOH/Na_2S$ ratio	PULP YIELD	
	Total %	Screened %
1-23/27	47.30	47.01
2-24/26	46.87	46.80
3-26/24	45.80	45.35
4-27/23	44.40	44.03

As seen in Table 1, while NaOH ratio is increased, the screened yield is decreased. The highest pulp yield has been calculated to be 47.1% in cooking No.1 ($NaOH/Na_2S$ ratio: 23/27).

5.1 Some of the Properties of Manufactured Papers

In Table 2, some of the properties of manufactured handsheets obtained from that pulp are presented.

TABLE II. Mean Screened Yields of Pulps and Some of the Properties of Manufactured Handsheets

Cooking no/SR°	Smoothness (ml/s)	Brightness (%)	Opacity (%)	Tear index ($mN.m^2/g$)	Burst index ($kPa.m^2/g$)	Breaking index (N.m/g)
1/16±2	455.6	18.2	99.9	9.1	2.8	47.0
/35	272.4	14.5	99.2	4.5	3.8	94.3
/50	256.8	13.3	98.6	4.2	4.4	99.3
2/16±2	338.0	20.2	99.8	7.0	4.2	49.5
/35	310.0	14.0	99.8	4.9	4.0	95.0
/50	196.5	13.4	98.5	4.6	4.4	98.7
3/16±2	388.0	21.0	99.9	9.8	2.6	47.1
/35	274.1	14.3	99.1	5.0	4.0	93.0
/50	247.3	13.8	99.0	4.7	4.2	96.6
4/16±2	498.4	22.7	99.8	9.2	3.0	48.8
/35	380.0	15.2	99.4	4.6	4.2	91.5
/50	376.0	14. 6	99.2	4.4	4.3	99.5

It can be seen that as the beating time increased, the surface smoothness, burst index and breaking length increased. But brightness, opacity and tear index decreased. The opacity value was found directly related to the light transmittance of the paper, and it increased as the color of the paper darkened. The opacity of low NaOH ratio pulp was found to be higher than that of the high NaOH ratio pulps. The opacity value of the papers decreased as the beating degree increased. The brightness value decreased as the beating level increased. Therefore, the brightness value was found to be greater at high NaOH pulp than low NaOH level pulp. Gençer and Şahin [10] have reported that the highest screened pulp yield was obtained at a low NaOH ratio, and the yield decreased because of the increase in the degradation of lignin and hemicellulose due the increased NaOH ratio.

The burst test is very important in sack papers, and packing papers. The bursting strength and breaking length of the unbleached redwood pulps were found better than those of the Douglas-fir pulp [2]. Mutjé et al. [11] found that sheets from olive prunings that were obtained by means of an organosolv process had a burst index of 3.02 kPa m^2/g. In our study, the burst index under optimum conditions was found to be 4.4 kPa.m^2/g, whereas this value was 3.85 kPa.m^2/g [1] in papers produced via the Kraft method from Populus tremula. Under these conditions, when burst index was considered, Sequia sempervirens was found better than Populus tremula and olive pruning wood.

VI. Conclusion

In the pulp production from redwood, the optimum conditions were determined as NaOH/Na_2S ratio as 23/27, because as NaOH ratio increases and Na_2S ratio decreases, screened yield decreases. The other parameters were determined as, solution/stalk ratio as 5/1, cooking temperature as 170±2˚C, and coking duration as 180 min.

Increasing NaOH ratio has improved the brightness value, burst index and breaking length. But the opacity value and tearing index were affected negatively. Execution of pulping at different temperatures and for different durations may change the results. For this reason, we recommend to use different temperature and duration parameters in further studies. Burst index and breaking length were increased by beating. If desired high burst index and breaking length, beating duration can be increased.

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